International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

NUTRIENT USE EFFICIENCY AS INFLUENCED BY IRRIGATION AND NUTRIENT MANAGEMENT IN BANANA UNDER PRECISION FARMING

[1*]G. J. SHIMI, [2]K. R. SHEELA

[1]Ph.D. Scholar, Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram-695522, Kerala, India

[2] Professor, Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram-695522, Kerala, India

*Corresponding author

ABSTRACT

An investigation was carried out for two consecutive seasons from February 2012 to November 2013 in the Instructional Farm of College of Agriculture, Vellayani, Kerala to study the effect of irrigation and nutrient management through fertigation and foliar nutrition on nutrient use efficiency (NUE) in banana under precision farming. The experiment was carried out in split plot design with six main plots and three sub plots, replicated thrice. Irrigation and nutrient management practices adopted in main plots included basin and drip irrigation with soil application of full dose of nutrients and drip fertigation using different water soluble fertilizers at 60 per cent of recommended dose. Foliar nutrition in sub plotsincluded 19-19-19 foliar spray, Sulphate of Potash (SOP) bunch spray and water spray. The study revealed that irrigation and nutrient management through fertigation and foliar nutrition had significant influence on NUE in both the years. Fertigation of 60 per cent N and K as urea and Muriate of Potash (MOP) and soil application of full P as rock phosphate was found to be effective in enhancing N and K use efficiency while P use efficiency was improved by fertigation of 60 per cent RDN as combination of 10-10-10, urea and SOP. Moreover, two bunch sprayings of SOP @ 2 per cent after complete bunch emergence and three weeks after first application significantly improved NUE. Foliar spray with 19-19-19 fertilizer @ 0.50 per cent at 2, 4 and 6 MAP was observed to be beneficial in improving the P use efficiency. It was also noticed that the treatment combination of 60 per cent RDN supplied as 10-10-10, urea and SOP along with SOP bunch spray enhanced NUE of all major nutrients in both the years.

Keywords: Banana, Fertigation, Foliar nutrition, Nutrient use efficiency, Precision farming

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

INTRODUCTION

Owing to the multiple uses of Banana, nowadays, a wide preference and acceptability of the crop among farmers and consumers has been observed. According to NHB (2013), there has been an increase in the area and production of banana to the tune of 66 and 87 % respectively in 2012-2013 compared to 2001-2002. Banana is a shallow rooted crop which requires a continuous supply of nutrients and water for its proper growth. In fact, the crop is being raised under traditional method of basin irrigation and soil application of nutrients in monthly splits. This inefficient crop husbandry practices adopted by banana farmers lead to poor utilization of nutrients and water resulting in wastage of inputs and decreased NUE. In this context, precision farming offers tremendous advantage in efficient and rational use of fertilizers and water for enhancing NUE. Through fertigation and drip irrigation, crop nutrient and water requirements can be met accurately. Deep ploughing and taking raised beds are the improved land management practices adopted in precision farming to provide precise rhizosphere environment for the effective utilization of the inputs. Moreover, foliar nutrition which is a widely accepted ecofriendly practice enable application of nutrient supplements directly to the crop canopy in limited amounts for rapid and efficient crop use. Hence, precision farming practices are gaining importance in the context of efficient use of nutrients and water which in turn increase the yield of the crop. With this background, the present investigation was conducted to study the effect of irrigation and nutrient management through fertigation and foliar nutrition on NUE in banana under precision farming.

MATERIALS AND METHODS

The present experiment was conducted in the Instructional Farm of College of Agriculture, Vellayani, Kerala during two consecutive seasons from February 2012 to November 2013. The experimental field was located at 8^o 25' 46''N latitude and 76^o 59'24'' E longitude and at an altitude of 19 m above mean sea level. The soil of the experimental site was sandy clay loam which belonged to the order oxisols, Vellayani series.

The experiment was laid out in split plot design with six main plots and three sub plots in three replications. Gross plot size was 24 m^2. Main plot treatments were n_1-soil application of full dose of nutrients with basin irrigation, n_2- soil application of full dose of nutrients with drip irrigation, n_3-drip irrigation alone without fertilizer, n_4-soil application of 100 % P as rock phosphate and fertigation with 60 % N and K as urea and MOP (Muriate of Potash), n_5- fertigation of 60 % RDN as 10-10-10, urea and Sulphate of Potash (SOP) and n_6- fertigation of 60 % RDN as 13-0-45, 0-0-50 and DAP (Diammonium Phosphate). The sub-plot treatments were water spray (s_1), foliar application of 19-19-19 @ 0.50 % (2, 4 and 6 MAP) (s_2) and bunch spray with 2 % SOP (after complete bunch emergence and three weeks after first application) (s_3).

Initial soil samples were collected from different parts of the field after land preparation and analysed for major, secondary and micronutrients. The general practices such as deep ploughing (50 cm), taking raised beds (30 cm height, 3 m width) and organic manure application (15 kg/plant) were uniformly followed. Pits of 50 cm x 50 cm x 50 cm size were taken at 2 m x 2 m spacing and lime @ 500 g/plant was applied to these pits. Tissue culture plants of banana 'Nendran' were planted in the centre of the pits and irrigation and shading were given to the plants for three weeks to ensure proper establishment of plantlets. Nutrient recommendation of Kerala Agricultural University @ 300:115:450 g NPK plant^{-1}year^{-1}was followed for the crop. For fertigation treatments (n_4, n_5 and n_6), 60 % of the recommended dose was used. In general, two hand weedings and one earthing up at 4 MAP were provided. Periodic desuckering was also followed up to bunch emergence.

In those plots receiving treatments as basin irrigation, uniform irrigation was given @ 5 l/plant daily up to 1 MAP (month after planting), @ 20 l/plant at 2nd and 3rd MAP and @ 40 l/plant from 4 MAP to two weeks before harvesting on alternate days. Irrigation schedule started from the third week onwards. Drip irrigation was scheduled daily to meet the crop water requirement. Irrigation water requirement through drip (volume in litres/plant/day) was computed using the following relationship based on the pan evaporation data.

IR = Epan x Kp x Kc x spacing x wetted area, where

IR = Irrigation requirement (mm)

Epan = Pan evaporation rate (mm) from U.S class A open pan evaporimeter

Kp = Pan co-efficient (0.75)

Kc = Crop co-efficient (initial stage- 0.50; mid stage – 1.10; late stage – 1.00) (FAO, 1998)

Spacing = 2 m x 2 m (4 m^2)

Wetted area = 0.70 m^2 (Reddy and Reddi, 2011)

To deliver water and fertilizer to the respective plots, five sub mains were laid out in the field. From each sub mains, two laterals were connected to the respective plots. On the laterals, drippers (pressure compensating) with a discharge rate of 8 L/h were connected to deliver water to individual plots. Fertigation was carried out using ventury unit. Fertigation was done at weekly interval and a total of 24 fertigations were given from one month after planting to one month after complete bunch emergence.

Nutrient use efficiencies in all the treatments were calculated using the following formula.

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

Nutrient Use Efficiency = Physiological efficiency x Apparent recovery efficiency (Goodroad and Jellum, 1988 and Craswell and Godwin, 1984)

$$\text{Physiological efficiency (kg kg}^{-1}) = \frac{\begin{array}{c}\text{Total dry matter yield} \\ \text{of fertilized crop (kg)}\end{array} - \begin{array}{c}\text{Total dry matter yield} \\ \text{of unfertilized crop (kg)}\end{array}}{\begin{array}{c}\text{Nutrient uptake by} \\ \text{fertilized crop (kg)}\end{array} - \begin{array}{c}\text{Nutrient uptake by} \\ \text{unfertilized crop (kg)}\end{array}}$$

$$\text{Apparent recovery efficiency (\%)} = \frac{\begin{array}{c}\text{Nutrient uptake by} \\ \text{fertilized crop}\end{array} - \begin{array}{c}\text{Nutrient uptake by} \\ \text{unfertilized crop}\end{array}}{\text{Quantity of nutrients added}} \times 100$$

$$\text{Agronomic efficiency (kg kg}^{-1}) = \frac{\begin{array}{c}\text{Yield} \\ \text{of fertilized crop (kg)}\end{array} - \begin{array}{c}\text{Yield} \\ \text{of unfertilized crop (kg)}\end{array}}{\text{Quantity of nutrients added (kg)}}$$

RESULTS AND DISCUSSION

1. Effect of nutrient sources and irrigation on nutrient use efficiency and agronomic efficiency of major nutrients

Nutrient use efficiency of major nutrients (Table 1) was significantly influenced by nutrient sources and irrigation in both the years. During first year, the highest nutrient use efficiency for N and K (18.38 kg kg^{-1} and 12.24 kg kg^{-1} respectively) were recorded by soil application of 100 per cent P as rock phosphate and fertigation of 60 per cent N and K as urea and MOP (n_4) which was on par with fertigation of 60 per cent RDN as 10-10-10, urea and SOP (n_5). Similar trend was observed in second year also with highest values of 19.71 kg kg^{-1} and 13.12 kg kg^{-1} respectively for N and K. Fertigation of 60 per cent RDN as 10-10-10, urea and SOP (n_5) registered the highest P use efficiency of 46.97 kg kg^{-1} and 48.24 kg kg^{-1} respectively in both the

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

years. But it was on par with fertigation of 60 per cent RDN as 13-0-45, SOP and DAP (n_6) during second year.

Table 1. Effect of nutrient sources, irrigation and foliar nutrition on nutrient use efficiency of major nutrients, kg kg^{-1}

	N		P		K	
	I Year	II Year	I Year	II Year	I Year	II Year
Nutrient sources & irrigation						
n_1	13.50	14.20	35.19	40.60	8.99	9.46
n_2	13.70	13.26	35.70	34.55	9.13	8.83
n_4	18.38	19.71	28.75	30.82	12.24	13.12
n_5	18.04	18.36	46.97	48.24	12.02	12.23
n_6	13.15	16.19	36.65	43.70	8.76	10.78
SEm (±)	0.862	0.832	1.949	1.450	0.574	0.554
CD (0.05)	2.814	2.713	6.358	4.730	1.872	1.807
Foliar nutrition						
s_1	13.26	13.85	31.36	33.90	8.84	9.23
s_2	16.29	16.92	38.76	41.65	10.87	11.29
s_3	16.51	18.26	39.84	43.20	10.97	12.13
SEm (±)	0.510	0.296	1.424	1.482	0.339	0.197
CD (0.05)	1.507	0.875	4.201	4.373	1.002	0.582
Interaction						
n_1s_1	11.46	13.36	29.89	36.87	7.64	8.90
n_1s_2	13.52	14.46	35.16	41.32	9.02	9.64
n_1s_3	15.53	14.80	40.52	43.61	10.33	9.84
n_2s_1	13.55	12.40	35.36	32.34	9.03	8.26
n_2s_2	13.28	13.50	34.54	35.10	8.86	9.00
n_2s_3	14.26	13.88	37.22	36.20	9.49	9.23
n_4s_1	15.55	17.08	24.34	26.74	10.36	11.39
n_4s_2	20.27	20.78	31.66	32.47	13.53	13.87
n_4s_3	19.33	21.25	30.26	33.26	12.84	14.11
n_5s_1	13.91	14.84	36.29	38.72	9.27	9.89
n_5s_2	20.10	18.06	52.14	53.19	13.42	12.05
n_5s_3	20.12	22.18	52.49	52.80	13.36	14.73
n_6s_1	11.85	11.57	30.93	34.81	7.90	7.71
n_6s_2	14.29	17.80	40.30	46.16	9.54	11.88
n_6s_3	13.31	19.21	38.72	50.12	8.84	12.76
SEm (±)	1.142	0.663	3.184	3.315	0.760	0.441
CD (0.05)	NS	1.958	NS	NS	NS	1.302

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

During first year, the agronomic efficiency of major nutrients (Table 2) was also observed to be significantly improved by (n_4) for N and K. However, it was on par with (n_5). During second year also, (n_4) recorded significantly higher values of N and K use efficiency (25.59 kg kg^{-1} and 17.05 kg kg^{-1} respectively) but it was on par with (n_5) for N and (n_6) for K. Regarding P use efficiency, n_5 recorded the highest agronomic efficiency of 59.79 kg kg^{-1} in first year but was on par with n_6 during second year.

Table 2. Effect of nutrient sources, irrigation and foliar nutrition on agronomic efficiency of major nutrients, kg kg^{-1}

	N		P		K	
	I Year	II Year	I Year	II Year	I Year	II Year
Nutrient sources & irrigation						
n_1	15.36	17.22	40.04	44.87	10.23	11.47
n_2	15.14	15.15	39.45	39.50	10.08	10.09
n_4	24.37	25.59	38.12	40.03	16.23	17.05
n_5	22.97	25.10	59.79	65.38	15.29	16.72
n_6	18.19	23.91	47.38	62.25	12.11	15.92
SEm (±)	1.388	1.267	2.067	3.221	0.924	0.845
CD (0.05)	4.526	4.135	6.743	10.505	3.013	2.756
Foliar						
s_1	14.14	16.92	33.65	40.13	9.42	11.28
s_2	20.40	21.91	47.01	50.99	13.61	14.62
s_3	23.08	25.35	54.20	60.09	15.34	16.85
SEm (±)	0.490	0.603	1.237	1.324	0.327	0.401
CD (0.05)	1.445	1.781	3.651	3.908	0.965	1.185
Interaction						
n_1s_1	13.15	13.25	34.31	34.57	8.77	8.83
n_1s_2	14.78	17.93	38.44	46.62	9.86	11.96
n_1s_3	18.15	20.47	47.36	53.41	12.07	13.62
n_2s_1	14.40	13.68	37.56	35.71	9.60	9.12
n_2s_2	14.78	14.11	38.44	36.68	9.86	9.41
n_2s_3	16.23	17.67	42.35	46.11	10.79	11.75
n_4s_1	15.50	19.23	24.26	30.11	10.33	12.82
n_4s_2	28.76	28.52	44.92	44.55	19.19	19.03
n_4s_3	28.86	29.03	45.18	45.44	19.17	19.28
n_5s_1	12.66	22.18	33.04	57.87	8.44	14.79
n_5s_2	25.99	22.32	67.40	57.89	17.34	14.90
n_5s_3	30.25	30.81	78.93	80.39	20.09	20.46
n_6s_1	14.97	16.26	39.07	42.42	9.98	10.84
n_6s_2	17.69	26.69	45.87	69.22	11.80	17.81

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

n_6s_3	21.92	28.79	57.19	75.11	14.56	19.12
SEm (±)	1.096	1.350	2.767	2.962	0.731	0.898
CD (0.05)	3.233	3.983	8.164	8.738	2.158	2.651

The results revealed that the nutrient use efficiency was enhanced by fertigation treatments. Fertigation treatments (n_4 and n_5) significantly improved N and K use efficiency over soil application of nutrients. Feigin *et al*. (1982) opined that enhanced nutrient use efficiency in fertigation was due to reduced leaching loss. Haynes (1985) explained that increased N availability through fertigation was due to reduced NO_3^- leaching as the NO_3^- ion tend to accumulate at the periphery of the wetted soil volume and at the soil surface midway between emitter. Increased K use efficiency was due to the reduced leaching loss as explained by Kafkafi and Yosef (1980) that some of the K ions under fertigation would be exchanged on the clay complex with binding sites in a uniform wetted volume. Results on P use efficiency indicated that though fertigation in general enhanced the P use efficiency, it was highest in fertigation using the liquid fertilizer 10-10-10. Since P in the liquid fertilizer is in a readily available form, its uptake was improved resulting in high P use efficiency. Bacon and Davey (1982) opined that drip fertigation would result in horizontal and vertical movement of native soil P near the outlet and remain near the soil surface and root zone. In other treatments, P was applied as rock phosphate and DAP. Rock phosphate, being an insoluble phosphatic fertilizer and DAP which was sparingly soluble in water might have resulted in low P use efficiency in n_4 and n_6. All the above mentioned reasons might have contributed to enhanced nutrient use efficiency in fertigation. Application of lower dose of nutrients in splits was favourable for increasing nutrient uptake by reducing the losses. Thomas (2001) also observed better nutrient use efficiency by drip fertigation in banana.

2. **Effect of foliar nutrition on nutrient use efficiency and agronomic efficiency of major nutrients**

Foliar nutrition had found to have tremendous effect on enhancing nutrient use efficiency. Bunch spray with SOP (s_3) had significantly increased nutrient use efficiency of major nutrients like N, P and K in both the years. During first year, it was found to be on par with foliar application of 19-19-19 (s_2). However, in second year, it was on par with (s_2) only on P use efficiency. With respect to agronomic efficiency, s_3 was significantly superior to all other treatments in both the years. The efficient nutrient uptake without considerable loss might have contributed to enhanced NUE in foliar nutrition.

3. **Effect of nutrient sources, irrigation and foliar nutrition on nutrient use efficiency and agronomic efficiency of major nutrients**

ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

Though interaction effect did not exert any significant influence on nutrient use efficiency of any of the major nutrients during first year, it showed significant effect on N and K use efficiency in second year. It was noticed that n_5s_3 registered higher values of N and K use efficiency which was on par with n_4s_3 and n_4s_2. In the case of agronomic efficiency, during first year, n_5s_3 significantly increased agronomic efficiency of N and K which was on par with n_4s_3 and n_4s_2. The same treatment recorded the highest agronomic use efficiency of 78.93 kg kg^{-1} for P. During second year also, n_5s_3 recorded significantly higher agronomic use efficiency for N, P and K but it was on par with n_4s_3 and n_4s_2 for N and with n_6s_3 for P. For K, n_5s_3 was on par with n_4s_3, n_6s_3, n_4s_2, and n_6s_2.

CONCLUSION

The present study revealed that fertigation of 60 per cent N and K as urea and MOP along with soil application of 100 per cent P as rock phosphate can increase N and K use efficiency while the P use efficiency will be improved by fertigation with liquid fertilizer like 10-10-10 in combination with urea and SOP. Bunch spray with SOP @ 2 per cent and 19-19-19 foliar spray also has beneficial effect on NUE. Hence, it could be concluded that application of nutrients and irrigation water by drip fertigation and foliar nutrition along with precise management practices is beneficial for the efficient use of nutrients by banana.

ACKNOWLEDGEMENT

I am greatly indebted to Kerala State Council of Science Technology and Environment, Pattom, Kerala for proving me financial assistance through research fellowship for successfully completing the project.

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ISSN: 2455-6939

Volume:03, Issue:03 "May-June 2017"

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